National Aeronautics and Space Administration


# The Orbital Debris Problem and the Challenges for Environment Remediation

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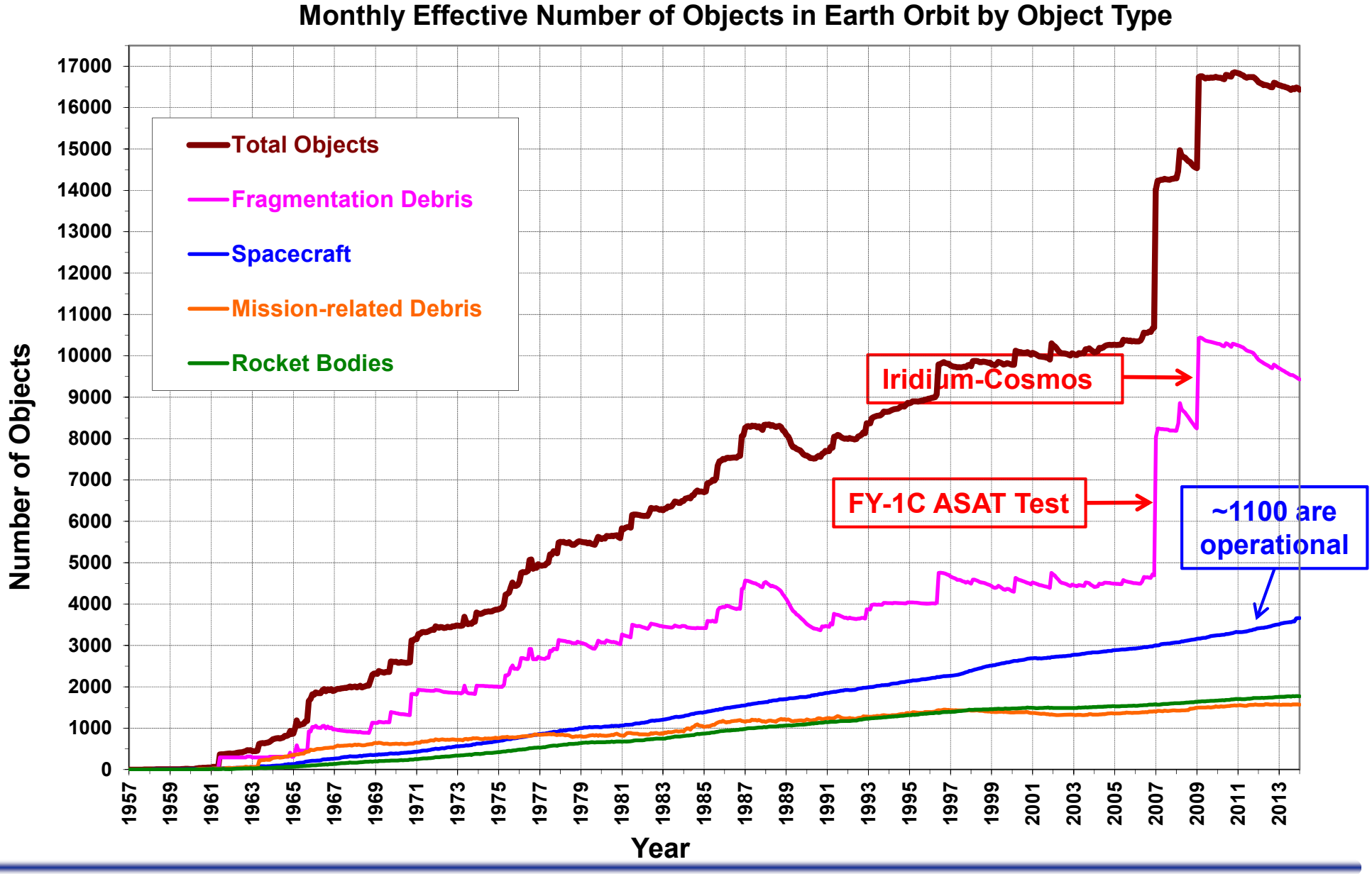
# Growth of the Cataloged Populations



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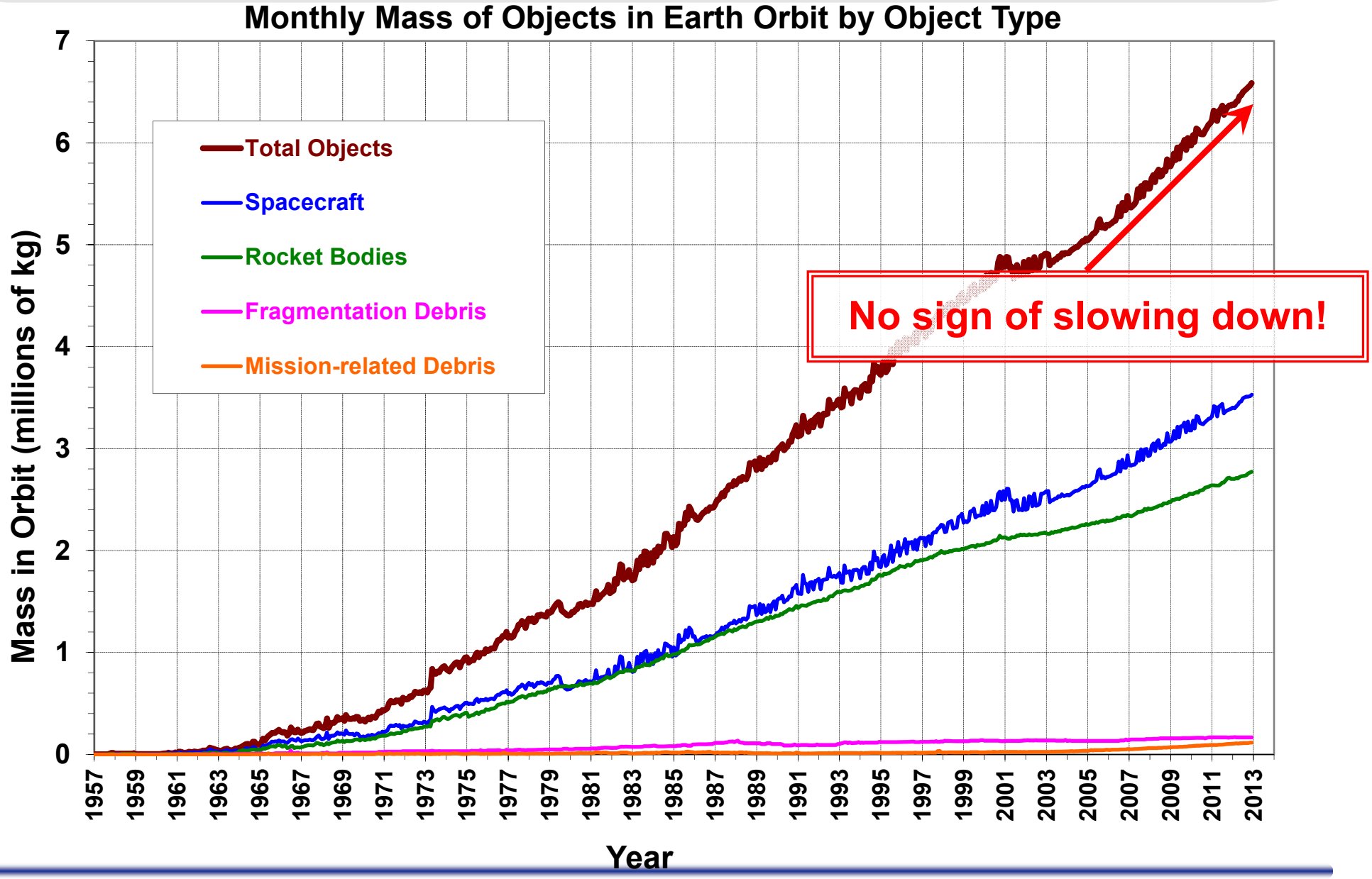
# Mass in Space



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# How Much Junk Is Currently Up There?


**Softball size or larger (≥10 cm): ~20,000 to 22,000 (tracked by the U.S. Space Surveillance Network, SSN)**

**Marble size or larger (≥1 cm): ~500,000**

**Dot or larger (≥1 mm): >100,000,000 (a grain of salt)**

- **Due to high impact speed in space (~10 km/s in LEO), even sub-millimeter debris pose a realistic threat to human spaceflight and robotic missions**
  - **1-cm Al sphere @ 10 km/s = 400 lb safe @ 60 mph**
  - **5-mm Al sphere @ 7 km/sec could penetrate a 2.54 cm thick Al wall**
- **Total mass: ~6300 tons LEO-to-GEO (~2700 tons in LEO)**

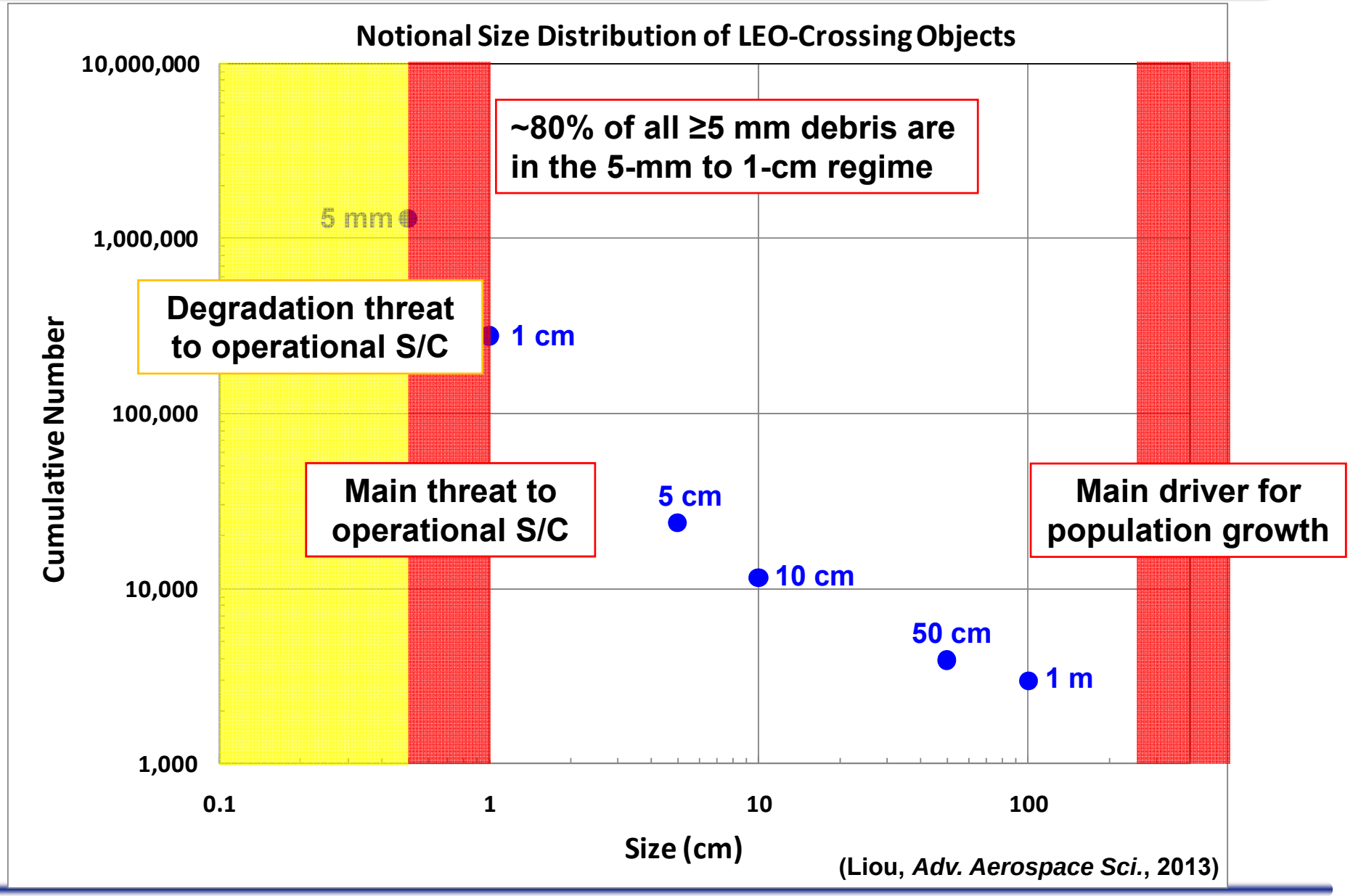
# Assessments of Future OD Environment


- **Future orbital debris population growth in LEO has been investigated by the Inter-Agency Space Debris Coordination Committee (IADC) since 2008**
- **An official comparison study was completed in 2012**
  - Study participants: ASI, ESA, ISRO, JAXA, NASA (lead), UKSA
  - Results from the six different models are consistent with one another
    - **Even with no future explosion and a global 90% compliance of the 25-year rule, the LEO debris population is expected to increase in the next 200 years**
    - **Catastrophic collisions involving intact objects (rocket bodies or spacecraft) are likely to occur every 5 to 9 years**
  - The study summary was presented to the United Nations COPUOS in 2013 and was widely cited, including a U.S. Congressional Research Report in 2014

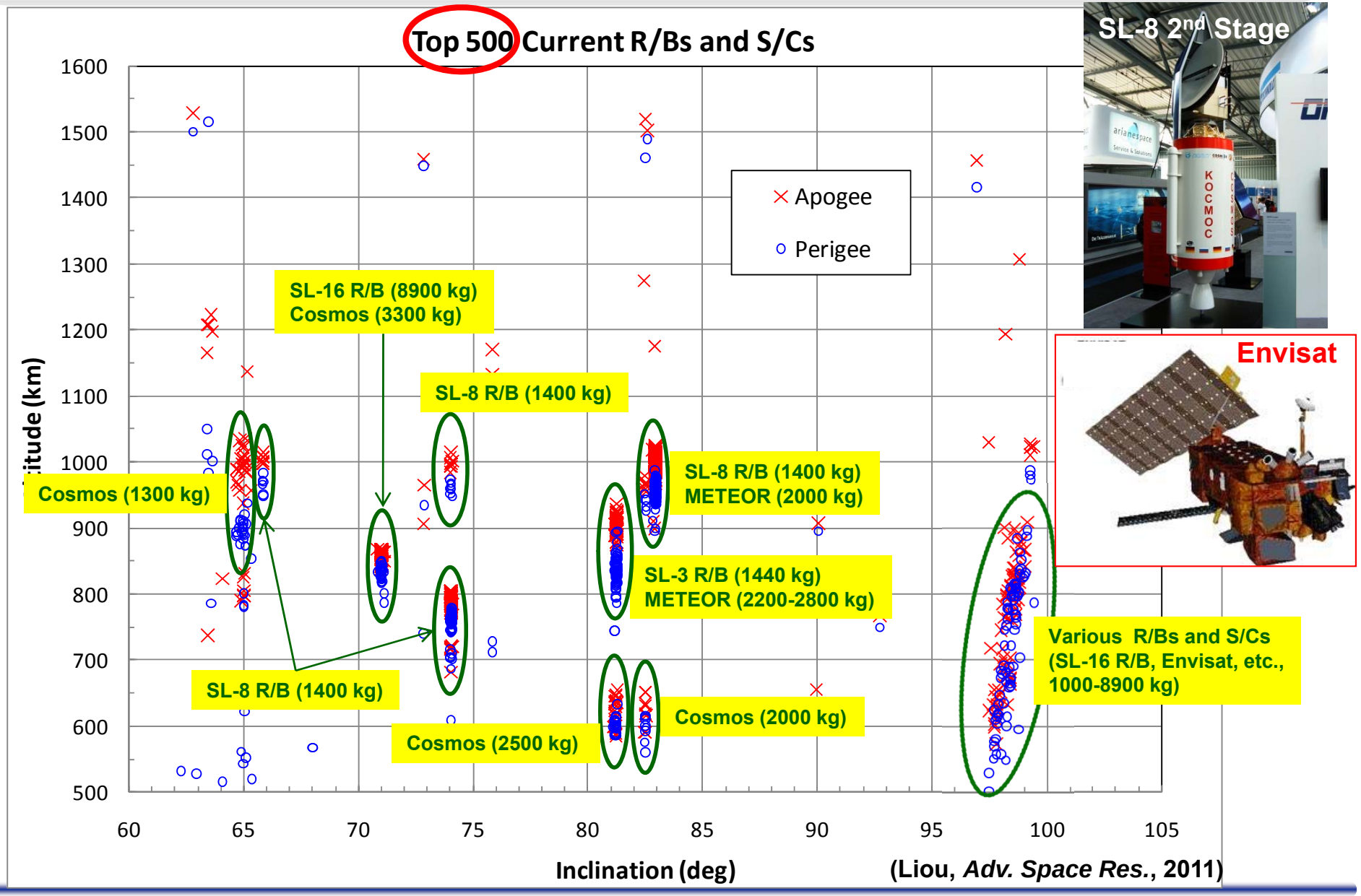
# Problems and Solutions


- **LEO debris population will continue to increase even with a good implementation of the commonly-adopted mitigation measures**
  - The root-cause of the increase is catastrophic collisions involving large/massive intact objects (rocket bodies or spacecraft)
  - The major mission-ending risks for most operational spacecraft, however, come from impacts with debris just above the threshold of the protection shields (~5-mm to 1-cm)
- **A <u>solution-driven</u> approach is to seek**
  - Concepts for removal of massive intacts with high $P_{collision}$
  - Concepts capable of preventing collisions involving intacts
  - Concepts for removal of 5-mm to 1-cm debris
  - Enhanced impact protection shields for valuable space assets

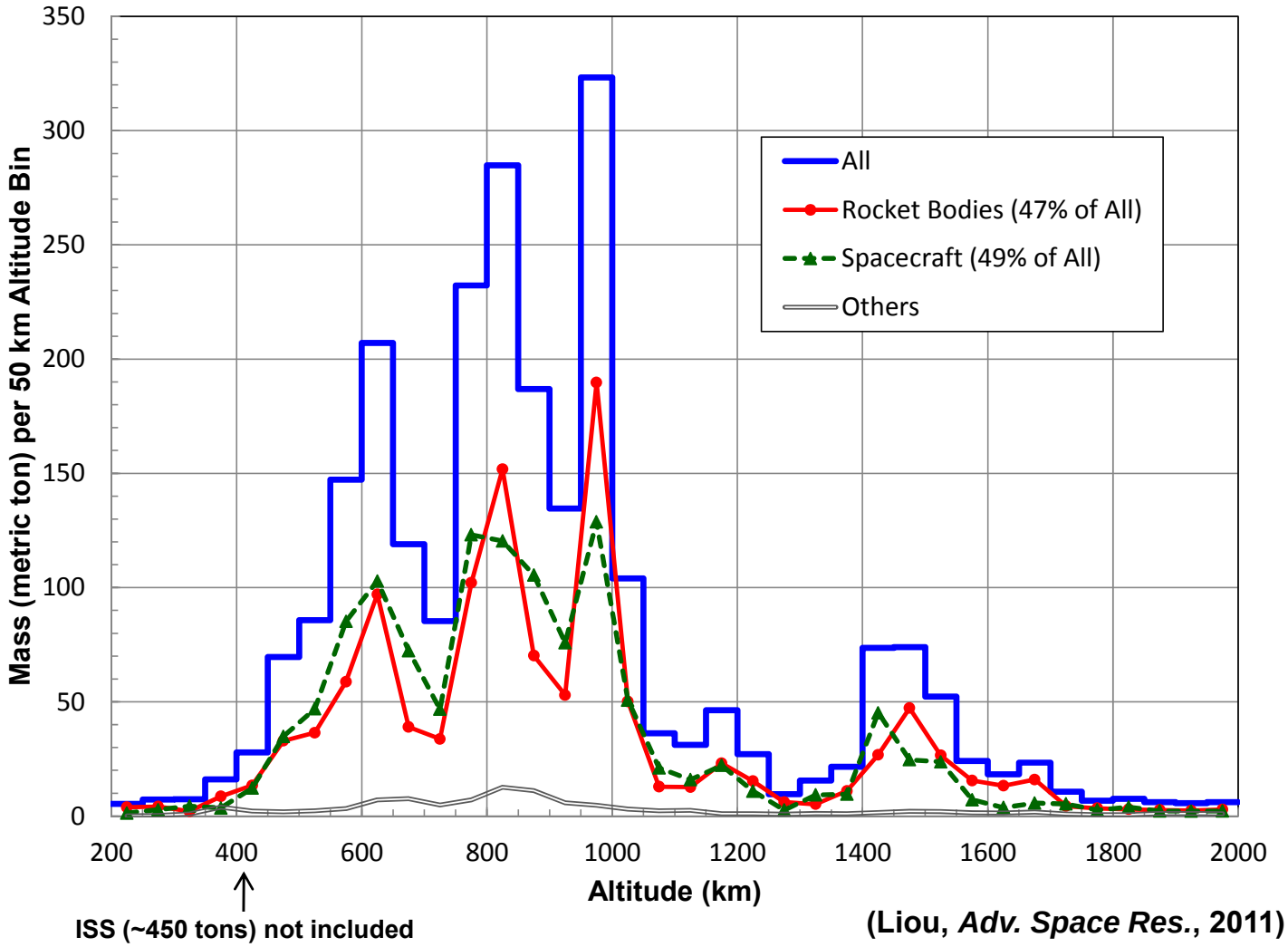
# Threat Regimes



# Intacts with High [ Mass × $P_{collision}$ ]



# Mass Distribution in LEO




- **Highest mass concentrations are in 800-1000 km altitude**
- **Contributions from spacecraft and rocket bodies are similar**

# Concluding Remarks


- **Key questions for remediation consideration**
  - What is the acceptable threat level?
  - What are the mission objectives?
  - What is the appropriate roadmap/timeframe for remediation?
- **Support advanced technology development when an economically viable approach is identified**
- **Address non-technical issues, such as policy, coordination, ownership, legal, and liability at the national and international levels**